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Virtual Workspaces for Web-based Emergent Processes

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Abstract
Organizations operating in increasingly competitive and volatile environments are turning to flexible organizational forms such as virtual teams and virtual organizations as solutions. Much of the work of such virtual organizational forms exhibits characteristics of emergence*. While the extension of workflow technology to deal with evolving processes is current research, this paper asserts that it is inappropriate for emergent processes. As an alternative, a model of workspaces, together with an underlying model of cooperation, is introduced. This model has been implemented in the* LiveNet *prototype system, which is presented. LiveNet is a Web-based workspace system which provides a context for cooperation without imposing a rigid process structure. Workspaces are seen not as static structures, but as highly flexible and dynamic, evolving along with the collaboration carried out in them. As LiveNet can be used over the Internet, it is of particular value to geographically dispersed virtual teams.*

Keywords: emergent process, virtual workspace, web-based collaboration

1. Introduction

Many of today's organizations are operating in increasingly competitive and volatile environments (D'Aveni, 1994; Naff, 1995). Under these circumstances, organizational flexibility and adaptation to change have become essential competencies required for an organization's survival. Concomitant, and related, has been a trend to establish new flexible organizational forms, integrating resources from otherwise separate organizational units, or even spanning entire organizations (Donlon, 1997). This creates *virtual teams* and *virtual organizations*, often only assembled for a limited period of time such as the duration of a project. It has been claimed that the organization of the 21st century will be made up of virtual teams and of networks of such teams (Lipnack and Stamps, 1999).

Where the virtual team not only integrates diverse functional areas but also geographically dispersed resources, the utilization of communications and computing technology becomes a key enabler. Indeed, the past years have witnessed a profusion of network-enabled systems supporting different facets of distributed cooperation. However, when work needs to be carried out through a computer system, the question arises which support system is most suited for the task. The 1990s saw the rise and widespread adoption of workflow technology, and attempts are currently being made to extend workflow to new areas such as distributed collaboration. While this may be appropriate for certain kinds of work processes, we believe

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that much of the work carried out by virtual, cross-functional teams has different characteristics and requirements for which workflow technology does not provide the most suitable form of support. The paper will therefore investigate characteristics of work processes and identify requirements for their support systems. It will then propose virtual workspaces as a solution and introduce a prototype workspace system that was developed by our research group.

2. Process Support

Work processes in an organization can be classified into a number of categories. We see them as being differentiated by following attributes:

1. *Predefinition*: the degree to which the work process is predefined.
2. *Determinism*: the degree to which the possible outcomes of the work can be determined in advance.
3. *Structural staticness*: the degree to which the structure of the work process is static.
4. *Repetition*: the degree to which the work process is repeated.

Different combinations of different levels of each attribute constitute a given category of work process. Two extremes can be identified, with all of the attributes respectively at a maximum or a minimum level. If all attributes are at the highest extreme, i.e. the work process is entirely predefined, completely deterministic, completely static and highly repetitive, it can be characterized as a *production process*. This type of process is very common in organizations and often constitutes high-volume core activities.

On the other hand, if all attributes are at their lowest extreme, i.e. the work process is entirely non-predefined, non-deterministic, highly dynamic, and not repetitive, it can be characterized as an *emergent process*. This type of process occurs in many kinds of organizations, and is closely associated with organizational innovation and improvisation (Moorman and Miner, 1998).

Between these two extremes stretches a continuum of different process types. For example, Hawryszkiewycz (1999a) has categorized different types of processes along similar lines: the degree to which tasks are predefined, and the degree to which task sequences are predefined. This can be shown diagrammatically as in Figure 1. The following four types of processes are then identified (Hawryszkiewycz, 1999a):

1. *Predefined processes*: Both tasks and task sequences are predefined in detail.
2. *Non-predefined processes*: Tasks are pre-defined, but their sequence is decided during process execution.
3. *Mixed processes*: These processes are a mix of predefined and non-predefined processes, with one type of process nested inside the other; e.g. a process where major steps are predefined, but where detailed tasks within each step are non-predefined.
4. *Emergent processes*: Both the tasks themselves and their sequence are non-predefined and emerge during process execution.

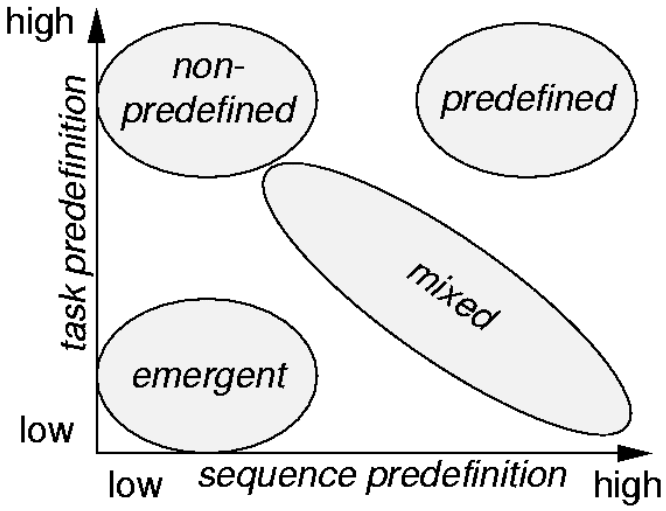

Figure 1. Process types related to task and sequence predefinition

Workflow management systems have traditionally supported production processes (named predefined processes in above classification). These processes need to be analyzed, modeled, and encoded in the workflow management system before they can be enacted through it. Their structure and outcomes are well-defined and subject to little change. Because of the effort involved in their analysis and modeling, it is usually only economical to do this for processes that are at least moderately repetitive. For these reasons, conventional workflow technology does not lend itself well for the support of emergent processes, given their poorly-defined, dynamic and non-repetitive nature.

Within the workflow community, efforts have been made to make workflow systems more flexible and to support work processes which are not always well-defined or deterministic; see for instance (Casati and Pozzi, 1999; Sadiq, 1999). These have centered on either accounting for alternatives to standard workflows, handling workflow evolution, or dealing with exceptions as they occur. However, in most cases the basic model of a largely deterministic and knowable process has remained unchanged.

The work of virtual teams, on the other hand, often does not have the predefined, deterministic characteristics well-supported by workflow systems. Teams may receive an initial high-level mission statement, such as "develop an innovative product for the European market", with little direction on how this mission is to be accomplished. Details of process structure and of individual task goals may then only be determined when the process is well underway, i.e. they *emerge* during process execution. Such processes are thus *improvisational* in nature (Moorman and Miner, 1998). They also tend to be highly knowledge-intensive, involving activities of knowledge sharing and creation (Nonaka, 1994). Such processes have been described in the literature as being "generally opportunistic in nature, result in disconnected and parallel work that must nevertheless be guided to a common goal" (Hawryszkiewycz, 1999b). This in turn places unique demands on a support system.

In the context of process management, Debenham (1999) has studied the special characteristics of emergent processes and concluded that, given their features, any management system should *support*, rather than attempt to *control* emergent processes.
We argue that the requirements of emergent processes demand a departure from the traditional process-centric and document-centric approaches supported by current workflow

management systems, and the adoption of a *work-centric* approach supported by a new generation of workspace-oriented systems. By work-centric we mean that the emphasis of the approach is in the support of the work that is carried out, whatever its structure may be, and the fulfillment of the work's goal. While document routing and process definition are involved to some extent (perhaps less directly than in workflow systems), these aspects do not take on a central role. Workspaces, in this connection, are seen as virtual spaces providing contexts for collaboration, bringing together people and knowledge sources required for carrying out a given work activity. Workspaces need to be highly flexible to allow for easy evolution along with the work carried out in them. As pointed out elsewhere (Hawryszkiewycz, 1999b), team formation and governance, provision of required knowledge sources, communication channels for geographically dispersed team members, and general tools all need to be supported by a workspace. However, and more importantly, they must be supported in a way that facilitates flexible, easy evolution aiding process emergence.

3. Workspaces

Physical cooperation takes place in physical space where all necessary tools, objects and people are assembled for the task at hand. For virtual cooperation, a virtual place provides the substitute.

Workspaces have been employed as a construct for this purpose in a number of systems. In many systems, workspaces are conceived as logical counterparts of physical spaces and are based on physical metaphors. For example, the TeamRooms system (Roseman and Greenberg, 1996) and MUDs (multi-user domains) (Churchill and Bly, 1999) are based on a metaphor of rooms which are connected by doorways. However, it has been argued that the application of spatial metaphors to virtual space is inappropriate (Harrison and Dourish, 1996). Instead, the importance of place rather than space is emphasized in collaborative environments; as stated by Harrison and Dourish (1996): *"Space is the opportunity; place is the understood reality"*. That is, what a place *is* is not so much a matter of its spatial features but rather what its users *do* within it and which turns a space into a place. Thus it is important that any virtual space creates the opportunity for users to appropriate it and turn it into a place for collaboration.

Furthermore, most systems employing workspaces lack an underlying model of collaboration. They usually only support the elements of cooperation, such as users, documents, tools and the workspaces themselves, without supporting the relationships between these elements which exist in actual collaborative settings.

We have developed a model of workspaces which aims at directly supporting these relationships. Although not based on any particular theory of organized activity, its main features are in agreement with theories such as that of Holt (1997).

A workspace is seen as supporting a particular organizational goal. Activity in the workspace thus corresponds to a goal-directed activity in the physical world. However, this goal is allowed to evolve over time and mutate as the process progresses and knowledge about it advances.

To achieve the goal, a workspace brings together a group of people. However, individual people don't act as themselves in a workspace, but always as the organizational entity they

represent (the "hat they wear"), and so take on a specific *role*. This is consistent with models of organized activity such as Holt's (1997) which state that every action is doubly performed, organizationally and personally. Therefore, organizational and personal performers of actions need to remain distinct entities in the workspace. It is through the assignment of people to roles that the organizational and personal performers of actions become linked, but these links are not permanent and can be changed as needed. Roles are associated with the workspace they are created for and are unique within that workspace, although different workspaces may have roles in common. Individual group members are assigned to roles as *participants* in the workspace's activity. A given individual may be involved in multiple workspaces in different roles. For example, someone may work as a team leader in one workspace, and as a design expert in another.

Within a workspace, roles perform *actions*, which can be grouped into two types: solo actions which are performed by a single action performer (a single role and participant); and interactions which involve multiple roles and/or participants. Interactions may be action-oriented such as joint editing tasks, or communication-oriented such as discussions.

Actions may operate on *artefacts* which are any objects that are consumed or produced by an action. These are usually documents of various types such as text, drawings, graphic images, etc. Here we distinguish between two types of artefacts: those which are the direct inputs or outcomes of an activity, and those which are used as background material. Company policies, norms, standards and the like are all examples of background material. Their content is assumed knowledge for those participating in the activity, and "required reading" for those who are not yet familiar with their content. By associating both background material (designated simply as *backgrounds*) and the directly operated-on documents (designated as *documents*) with a workspace, and by distinguishing between them, newcomers to a workspace are aided in "getting up to speed" with the work carried out in it.

Roles, actions and artefacts are related to each other through a *governance structure* which can be conceptualized as being overlaid onto the workspace elements. It defines what a role can do with respect to artefacts and actions, and also with regard to other roles. This corresponds to the relationships that exist in actual work settings. For instance, the coordinator of a collaborative research team may be the only one to release a new research plan, while every other team member may be allowed to read it. On the other hand, the coordinator may at one point choose to temporarily make a research plan available to individuals outside the team, such as to a group of external experts, if the work process requires it. The coordinator may even choose to assign the right to release research plans to other roles in the workspace. These examples illustrate governance relating three types of workspace elements: a role (coordinator), an artefact (research plan), and an action (release). However, governance is also dependent on organizational norms and culture which may vary greatly from one group to another, and thus from one workspace to another. In this regard, emergent processes have been described as *personal*: "what works for one group of people may not work for another group" (Debenham, 1999). Therefore, governance for emergent work must be highly customizable, while at the same time providing sensible defaults to prevent overly time-consuming customization.

Because of its improvisational nature, emergent group work tends to be more communication-intensive than production processes. Therefore, in addition to the above workspace features, communication facilities are essential for workspaces. Informal

communication can be handled using actions, as described above, providing for example electronic mail and discussion fora. The latter are supported in workspaces in a dual role: on the one hand they constitute actions, on the other hand they are also artefacts inasmuch as they contain a record of the group's discussions, which makes them important for newcomers joining the group who need to learn about the issues of importance to the group.

For more formal communication requirements of the more structured and well-defined aspects of the work activity, special support is required. This is particularly of use for those types of processes which lie somewhat outside of the area of purely emergent processes, or for those which contain some more defined portions within an overall emergent process. Therefore, our model provides a number of types of workspace elements which together facilitate *notification*. These are used to convey asynchronously from one role to another (possibly across workspace boundaries) that a given kind of event has occurred. The notification takes place using semi-structured *messages* of a given *message type*. Each workspace can possess a number of message types, each representing a different kind of notification event. Messages are then sent according to *message rules* which represent defined communication channels within the organization and associate pairs of message types and their respective workspaces as well as the receiving role with each other.

The given model of workspaces does not place any temporal restrictions on workspace evolution. On the contrary, continuous modification and evolution are seen as key requirements for the support of highly flexible emergent processes. Very little may be known about an emergent process in advance except perhaps for its general structure: the main activities, roles and some major artefacts involved. Consequently, a workspace must be allowed to be initially defined just in terms of these general features. Later, however, as the work progresses within the workspace, more process requirements emerge and more details need to be added to the workspace. For instance, it may be necessary to spontaneously start a discussion among the members of a group, or to add notification support between certain activities, or to adapt the governance structure applying to a specific role in the workspace, etc.

A meta-model of the workspace elements discussed above and their relationships is shown in Figure 2. Note that issues of governance have been deliberately omitted to prevent the graph from becoming overly complex.

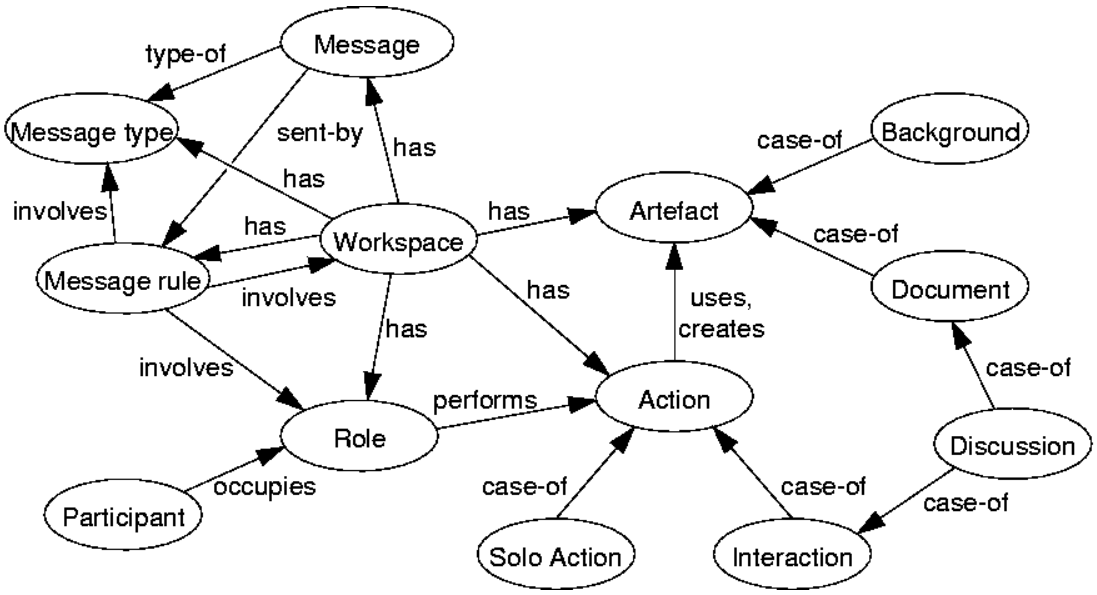

Figure 2. Meta-model of workspaces and their elements

4. Example

To illustrate the use of workspaces, consider an example involving collaborative research. In such research, a number of major activities may be identified, such as research planning, carrying out a number of subprojects, carrying out a number of experiments, etc. For each of these activities it may be known which roles and which major artefacts are involved, but the details of each activity may not be known in advance and may be left for later definition.

To facilitate the design of workspaces, we use a diagrammatic notation which is an adapted version of rich pictures taken from Soft Systems Methodology (Checkland, 1981) and which has been modified for this purpose (Hawryszkiewycz, 1997). This notation captures the main elements of an emergent process: roles, activities and artefacts, and their relationships with one another.

A rich picture representation of the given example is shown in Figure 3. Here, the clouds represent activities, the rectangles artefacts, and the human figures roles. The lines linking roles and activities signify involvement of the roles in the activities. The arrows linking artefacts and activities signify involvement of the artefacts in the activities: production or modification (if pointing to the artefact), and consumption (if pointing from the artefact). Only one subproject and experiment are shown in this figure for reasons of simplicity, but a real case would involve multiple instances of each.

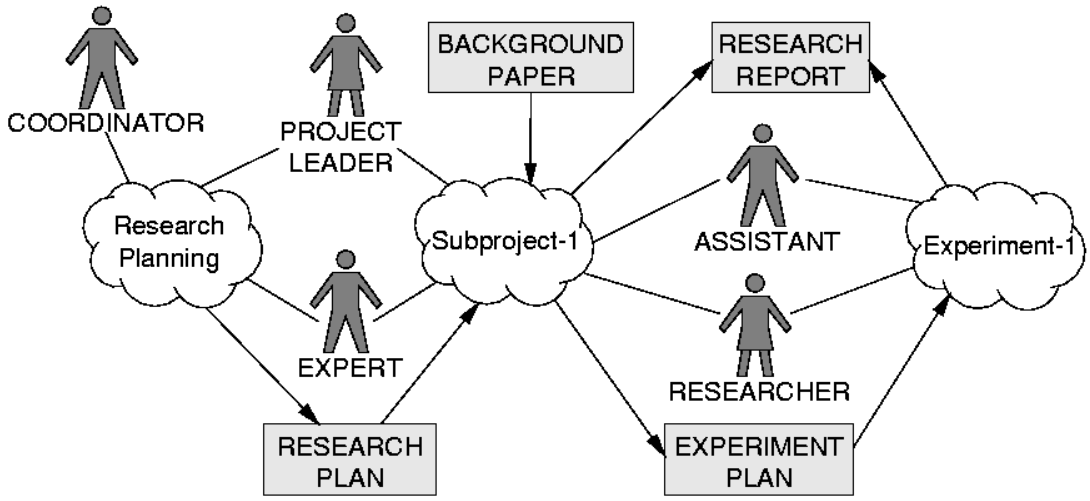

Figure 3. Rich picture of a collaborative research process

The rich picture shows for instance that the Research Planning activity involves the roles Coordinator, Project Leader and Expert, and produces the artefact Research Plan. As can be seen, some of the roles are involved in more than one activity, and the artefacts produced by one activity may be involved in other activities. That is, there is some *coupling* between activities.

A mapping from this process structure into a suitable workspace structure can now be performed according to three rules: (1) activities in the rich picture are mapped into workspaces; (2) roles involved in a particular activity become roles defined in a particular workspace, and (3) artefacts in an activity become artefacts in a workspace. Thus the rich picture process representation is mapped into the following:

Workspace: Research-Planning
Roles: Coordinator, Project Leader, Expert
Artefacts: Research Plan

Workspace: Subproject-1
Roles: Project Leader, Expert, Researcher, Assistant
Artefacts: Research Plan, Background Paper, Experiment Plan, Research Report

Workspace: Experiment-1
Roles: Researcher, Assistant
Artefacts: Experiment Plan, Research Report

Note the overlap between some of the sets of roles, and likewise between some of the sets of artefacts. If a role is involved in more than one workspace, it is a member of each workspace and needs to be defined in each. The same applies to artefacts.

This set of workspaces represents only an initial state. As work progresses, new requirements will emerge which will lead to the evolution of workspace structure and content, to the creation of new workspaces, and to the creation of links between workspaces.

To illustrate process emergence, we will consider a concrete scenario. This will illustrate four points: (1) the emergent properties of work; (2) the need to quickly set up new workspaces to deal with unexpected situations; (3) the separation of role and actor (i.e. participant); and (4) the need to dynamically, and temporarily, modify governance structures in response to process emergence.

This scenario involves a research project which is concerned with collaborative knowledge sharing. The research started with planning and has advanced to the stage where one subproject is underway whose mission is to identify requirements of knowledge sharing activities. This subproject is currently already carrying out an experiment involving an existing knowledge sharing application. Essentially the situation at this point corresponds to the rich picture shown in Figure 3.

As the work of the subproject progresses, one if its team members reports having read about another research project elsewhere conducting very similar research, but using an agent-based approach. This news is of great relevance to the current project and it is immediately decided to investigate the work of the other project. However, as none of the team members has extensive knowledge in the area of agent-based systems, external experts need to be brought in. The team leader, Maria, decides to set up a new sub-team headed by one of the members of her own team. The leader of the new sub-team, Rajesh, is given a mission statement to investigate the other research project's work, but is not given any detailed work plan. Maria also tasks him with finding external experts on agent-based systems to assist in the investigation and to notify her immediately of any important findings. For this purpose, she sets up the following things:

- A new workspace "Investigation".
- Three roles in the new workspace: leader, external expert, and assistant.
- Customization of privileges for the different roles: privileges to open, add, and delete documents, discussion fora, and actions for the leader role. Also, the privilege to add participants with the role of external expert is delegated to the leader temporarily, for the duration of the investigation. Privileges to open and add documents, and to participate in discussions to the other two roles.
- Two participants in the new workspace: one, Rajesh, assigned to the role of leader, the other to that of assistant. No participants are assigned to the role of external expert yet, which is left for the leader to do later.
- One document, the research plan, which is copied from the subproject workspace.
- A message type "investigation result" in the Subproject-1 workspace. This will be used by the leader of the investigation to send notification messages to the subproject leader.

Rajesh, the leader of the investigation, in turn, sets up following things:

- A message type "investigation result" in the Investigation workspace.
- A message rule linking the "investigation result" message types in the Investigation and Subproject-1 workspaces.

- Experts are assigned to the role "external expert" in the Investigation workspace as soon as they are located.

- A discussion forum in the Investigation workspace used by its members to discuss their investigation with one another.

The total setup effort is limited to only several simple actions on the part of the two team leaders. Work in the new workspace can now commence, with all (initially) required resources in place, very soon after it emerged that this work needed to be done.

In the next section, we will use this scenario to illustrate the use of our prototype workspace system LiveNet.

5. LiveNet Prototype

Based on the ideas of workspaces outlined earlier, our research group has developed the prototype system *LiveNet*. LiveNet provides the user with means for creating workspaces and defining the workspace elements described earlier. Workspace definition and dynamic evolution are facilitated so as to support the requirements of emergent processes as discussed in Section 2.

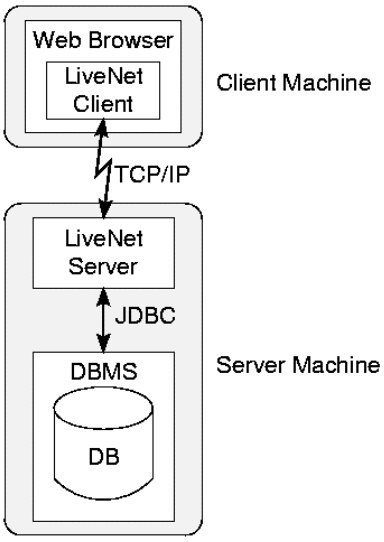

Figure 4. LiveNet's three-tier architecture

LiveNet is implemented as a three-tier system: users work with a LiveNet client which runs as a Java applet from a Web page and which communicates with a LiveNet server. This server in turn communicates with a relational database management system in whose database the workspaces, their elements, and related items are stored. The LiveNet three-tier architecture is depicted in Figure 4. Because the LiveNet client is implemented as a Java applet running in a Web browser, it essentially extends the scope of cooperation to that of the Internet—regardless of location of its participants. This is of particular importance to geographically dispersed virtual teams. It also makes it easy for first-time users to get started with LiveNet by only requiring a computer with an Internet connection and a Web browser. For end-users who do not need advanced workspace definition commands, a simpler, HTML-

only interface to the LiveNet server also exists.

All of the conceptual elements of the workspace model introduced in Section 3 have been implemented in LiveNet. The system provides actions dealing with workspace creation, setup and customization, as well as other commands of use during collaboration. In addition, LiveNet can be dynamically augmented with add-ons that provide functionality not found in the core LiveNet system. One example where this is being used is the creation of wizards which guide the user in the setup and customization of workspaces.

To demonstrate the use of LiveNet, we apply it to the collaborative research scenario given in Section 4. Initially, the three workspaces Research-Planning, Subproject-1 and Experiment-1 are created, and roles and artefacts added, corresponding to the rich picture that was shown in Figure 3. The LiveNet interface at this point, capturing the state of the "Research-Planning" workspace, is shown in Figure 5. It shows windows giving access to the workspace's documents, roles and participants (other windows used for accessing other workspace elements also exist but are not shown).

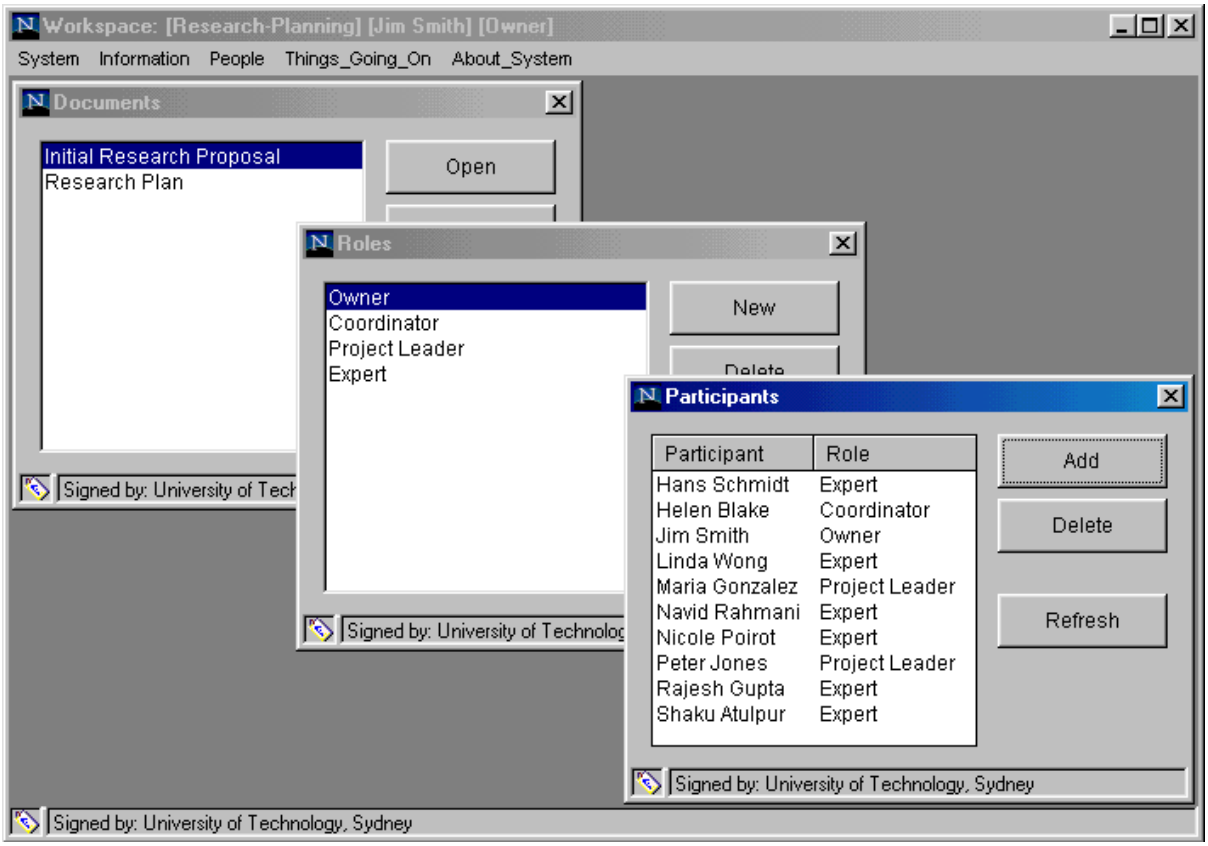

Figure 5. Research-Planning workspace with all pre-planned elements

Now, the scenario unfolds: the need to investigate the agent-based research project emerges, and the group leader needs to respond. She creates a new workspace using a Create-Workspace wizard, which allows her to assign all needed workspace elements from her own workspace to the new workspace, create roles needed in the new workspace, delegate authority to these roles, assign participants to the roles, etc. For example, Figure 6 shows her copying documents to the new workspace, and Figure 7 shows her assigning authority to the

new leader role. She also creates a message type in her own workspace, as mentioned in Section 4.

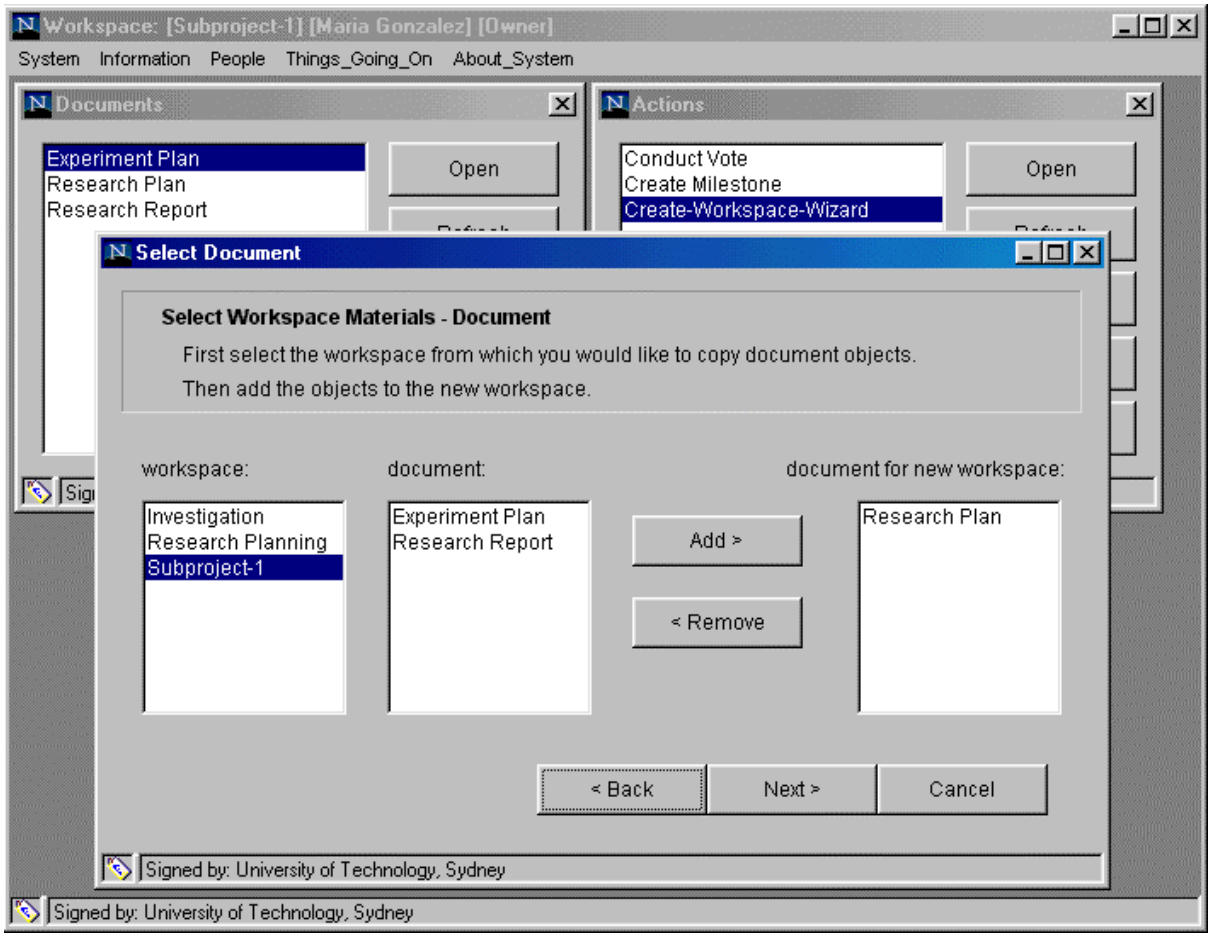

Figure 6. Using a wizard to copy documents into the new investigation workspace

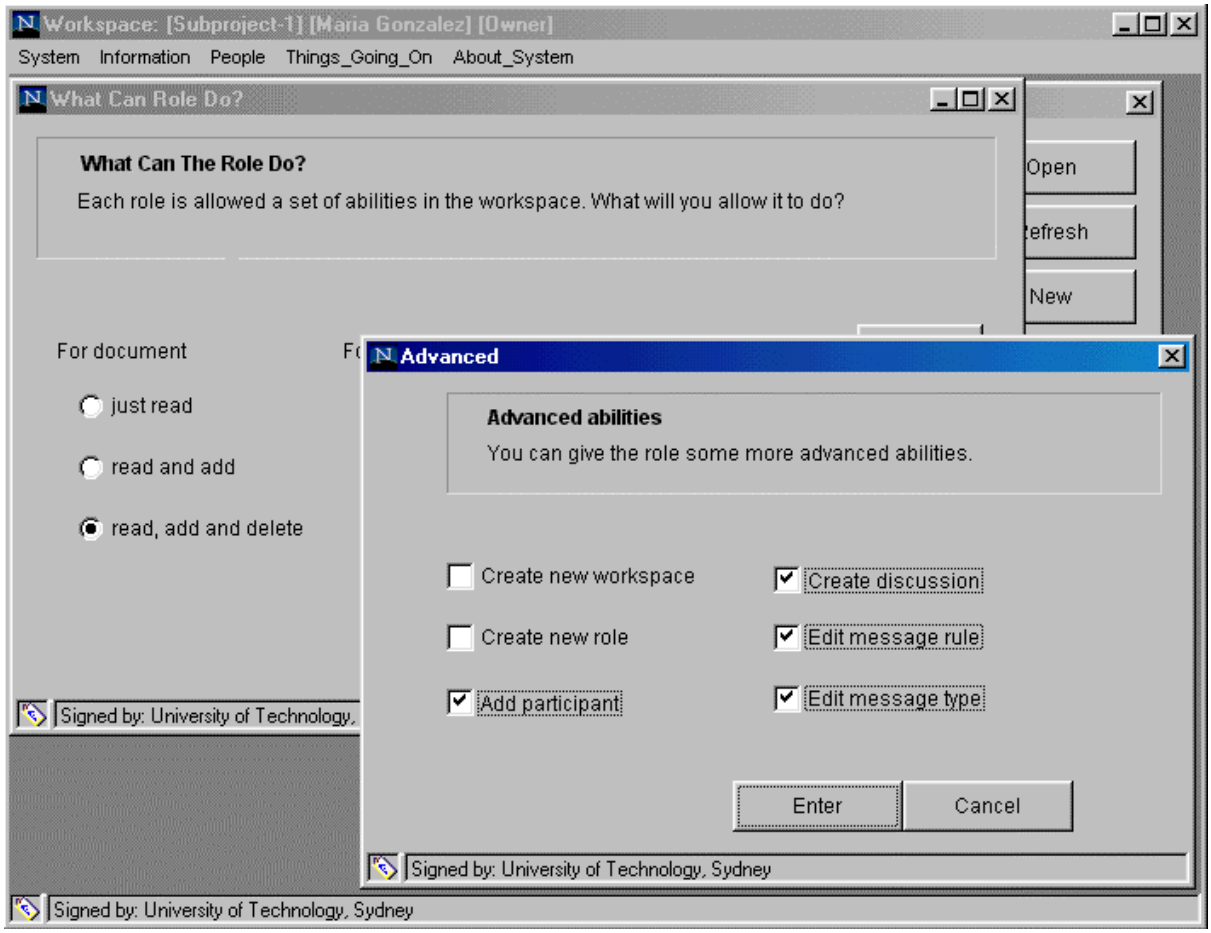

Figure 7. Using a wizard to delegate authority to the leader of the new investigation workspace

The leader of the new investigation workspace, on the other hand, creates the message type and message rule in the new workspace (shown in Figure 8), sets up a discussion forum and assigns the experts, once found, to the workspace. Work then progresses until the mission is accomplished, upon which the leader returns to his previous work in the Subproject-1 workspace. In this way, an unexpected situation that emerged was dealt with flexibly and swiftly. This is a typical example of improvisation, with planning and implementation of an action converging (Moorman and Miner, 1998).

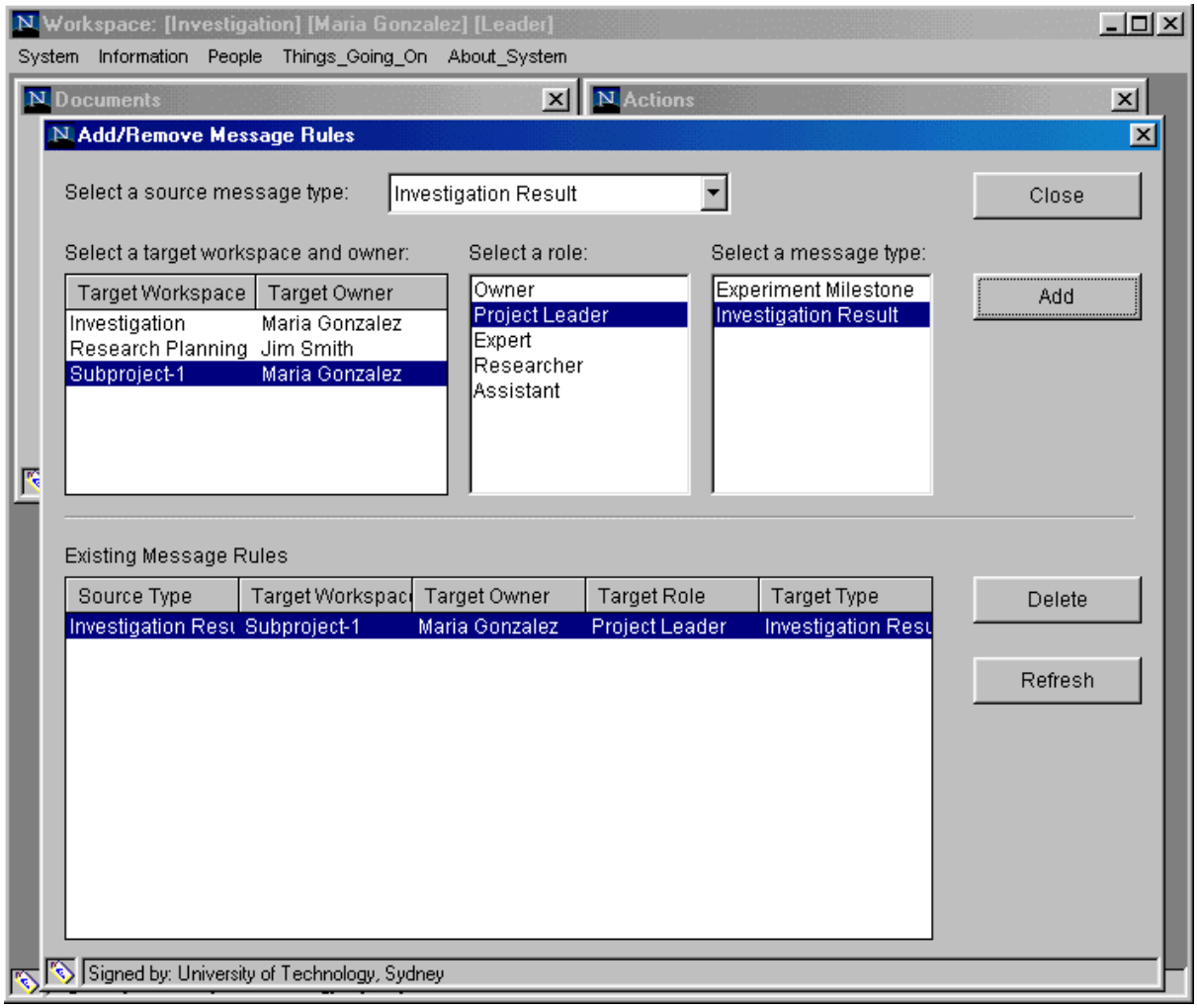

Figure 8. Creating a message rule for notification about investigation results to the Subproject-1 workspace

This example also showed how the inter-connected nature of work, common in the real world, is reflected in the workspaces—the shared artefacts in use in different workspaces, the shared people with different roles, the communication channels, in the form of message rules, etc. These and other relationships between workspaces allow more than simply a collection of independent workspaces to be set up, but rather inter-connected workspace networks to be created and to dynamically evolve together.

6. Related Work

Much work has been carried out developing Web-based and other Internet-based tools that support various aspects of virtual work, and indeed many of these systems support the notion of workspaces in some form, either explicitly or implicitly. Different categories of such systems can be identified, among which are document-centric, tool-centric and place-based systems. Document-centric systems focus on the sharing and management of documents among a group of users over the Web. In this category, the BSCW system (Bentley et al., 1997); TeamNow (TeamNow, 2000), a system based on BSCW; HotOffice (HotOffice, 2000); ICE (Farshchian and Divitini, 1997); and others can be found.

Tool-centric systems emphasize the provision of a multiplicity of tools of use in collaboration. An example is the CORE system (Schur et al., 1998) which supports experiment-oriented scientific collaboration and shared access to remote resources and equipment. Many systems in the place-based category, mentioned below, can also be characterized as tool-centric, for example TeamWave Workplace.

Place-based systems[1] focus on the provision of virtual places for collaboration, which can be equipped with necessary tools and documents. TeamWave Workplace (formerly TeamRooms) (TeamWave, 2000; Roseman and Greenberg, 1996) is one such system which provides virtual spaces called *rooms* that can be connected with one another through *doorways*; Collaborative Virtual Workspace (CVW, 2000; Spellman et al., 1997) is another such system which organizes virtual spaces (rooms) into larger units (floors and buildings). Both of these systems support both synchronous and asynchronous work within the virtual rooms and provide persistent storage of artefacts. Another system that can be categorized as place-based (and which does not employ space-based metaphors) is Orbit (Mansfield et al., 1999) which provides *locales* that bring together people and objects.

What these systems have in common is the provision of virtual spaces for document sharing, and some of them also provide support for a virtual team's communication requirements. What they lack, however, is a model of collaboration on which the implementation is based (with the partial exception of Orbit). None of the mentioned systems distinguishes between organizational and personal performers of work, i.e. the separation between role and participant in a workspace. These systems are as such ad-hoc in their support of collaboration. LiveNet, on the other hand, is based on such a model of collaboration, which makes the elements of collaboration, their relationships to one another, and their governance explicit, and thereby more closely aligns with actual work structures. Furthermore, as emergent work is carried out in networks of connected workspaces, process structures emerge which require some form of support. Message-based notification, as provided by LiveNet, can be used to facilitate process management requirements, including communication and coordination between and within work activities. While formal evaluations of LiveNet are still to be undertaken, initial observations from its use indicate that LiveNet is well suited to the requirements of emergent work.

7. Conclusions

Organizations facing competitive pressures and operating in volatile environments are increasingly utilizing flexible organizational forms such as virtual teams and virtual organizations. This paper has discussed the suitable forms of process support for virtual teams, particularly when their work is not of a standard, predefined nature. It has asserted that workflow technology, although appropriate in other contexts, is not suitable for the support of such work, and that instead systems based on workspaces are more appropriate. Workspaces provide a context for cooperation without imposing a rigid process structure. They thereby offer a great deal of flexibility and the potential to dynamically evolve along with the collaboration carried out in them. A particular model of workspaces was then introduced, and a prototype system implementing this model was presented. This system is Web-based and allows any Internet user to join into a collaboration through their Web browser, which is of

[1] As Harrison and Dourish (1996) would argue, "space-based" would be a more appropriate designation, as most of these systems are based on spatial metaphors.

particular benefit to geographically dispersed virtual teams.

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